

**Swan Ponds Mid-Summer Temperatures
Technical Report
(Follow-up Field Evaluation)**

Clark County Public Works
Water Resources Section

August 10, 2004

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Funded by the
Clark County NPDES Clean Water Program



Background

This technical memo summarizes a follow-up field evaluation to the previous Swan Ponds stormwater facility temperature monitoring study done by Clark County Water Resources in 2003 (Schnabel, 2004). One of the main findings of the earlier work was that the average daily maximum temperature for waters exiting the Swan Ponds was 3.28 ° F warmer than that for waters entering the ponds. Most of the previous study's background information still generally applies. However, it was assumed that the facility's outlet overflow structure "skims off the uppermost layer of pond water and discharges it downstream." Even though the study identified a probable heating impact from the ponds, further monitoring still needed to be done to determine the specific impact of the outlet structure on exiting water temperatures.

Purpose

The purpose of the current monitoring effort is to evaluate the temperature of waters entering the outflow structure and throughout the depth of the Swan Ponds facility to support temperature mitigation management options. A warm mid-summer day was chosen to monitor the facility's water temperature during a "worse case" heating period.

Methods / Quality Control

Temperature measurements were made with an YSI-85 multi-parameter field meter. Prior to field measurements, the accuracy of the YSI-85 temperature readings was checked against a National Institute of Standards and Technology (NIST) traceable thermometer by immersing the probes' sensors into a 5 gallon bucket of water at room temperature. The NIST thermometer read 21.01 degrees Celsius versus a reading of 21.1 degrees Celsius for the YSI-85. The precision of the readings was deemed adequate.

Multiple water temperature readings were made using the YSI-85 meter at various sites within the Swan Ponds facility over a one hour period during mid-day July 23, 2004 (see Figure 1). A temperature reading was first taken in the mid-channel of the inflowing stream to the upper pond of the Swan Ponds stormwater facility. This was followed by pond water column temperature readings at three pond sites. A canoe was utilized to access the pond sites and to minimize any mixing of the potentially stratified pond waters. At two of the pond sites, approximately 5 feet west of the lower Pond's outlet pipe and in the middle of the lower pond, measurements were made at 0.5 foot increments from the surface to the bottom. A measurement was also taken from the middle of the upper pond's well mixed outflow where it enters the lower pond. Additionally, a water temperature reading was taken of the lower pond's outflow where water spilled through a shallow notch at the top of the pond's vertical riser outfall pipe. A final water temperature measurement was taken at the same site as the first; the inflowing stream to the upper pond.



Results / Discussion

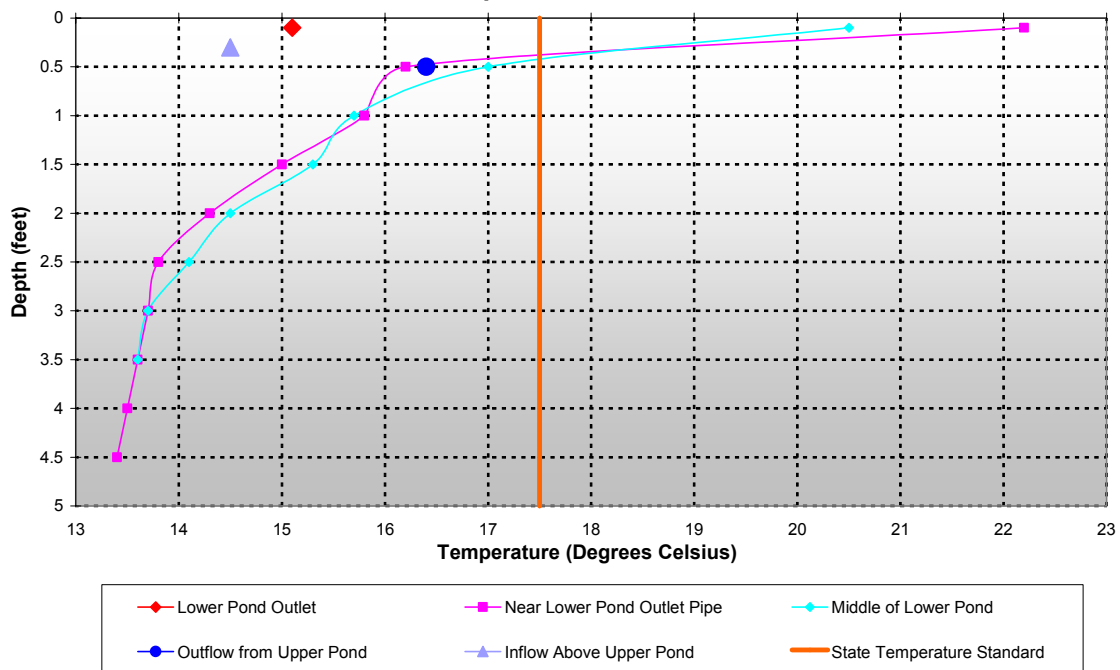
The results of the field temperature measurements are presented in Table 1 and Figure 2.

Table 1. Swan Ponds Temperatures at Various Sites During Middle of Summer Day

Date	Time	Staff	Instrument	Location	Station	Depth from Surface (ft)	Temperature (Degrees C)
7/23/2004	13:44	BH, JW	YSI 85	Below Lower Pond	At Top of Outlet Intake	0.1	15.1
(Outflow seen drawn from all depths)							
7/23/2004	13:23	BH, JW	YSI 85	Lower Pond	Near Outlet Pipe	0.1	22.2
	13:25				(Approx. 5 ft west of overflow)	0.5	16.2
	13:26					1.0	15.8
	13:27					1.5	15
	13:27					2.0	14.3
	13:27					2.5	13.8
	13:27					3.0	13.7
	13:27					3.5	13.6
	13:27					4.0	13.5
	13:27					4.5	13.4
	13:27					5.0	Bottom
7/23/2004	13:37	BH, JW	YSI 85	Lower Pond	Middle / Deepest Pool	0.1	20.5
	13:37				(Middle of Lower Pond)	0.5	17
	13:37					1.0	15.7
	13:37					1.5	15.3
	13:37					2.0	14.5
	13:37					2.5	14.1
	13:37					3.0	13.7
	13:37					3.5	13.6
	13:37					4.0	Bottom
		BH, JW	YSI 85	Upper/Lower Ponds	Upper Pond Well Mixed Outflow		
7/23/2004	13:32				(Where it Enters Lower Pond)	0.5	16.4
7/23/2004	Begin: 12:57	BH, JW	YSI 85	Above Upper Pond	Well Mixed Inflow to Upper Pond	0.3	14.5
7/23/2004	End: 13:55	BH, JW	YSI 85	Above Upper Pond	Well Mixed Inflow to Upper Pond	0.3	14.5

QA/QC: Thermometer Precheck: 7/23/04 10:00, NIST Traceable: 21.01 Deg. C., YSI 85: 21.1 Deg. C.

**Figure 2. Swan Ponds July 23, 2004
Temperature Profiles**



Importantly, it was observed while measuring the outflow temperature that the contributing volume of water entering the outflow came from various depths around the riser before spilling over into it. This was based on the movement of visible particles suspended in the upwelling water. The outflow water's relatively cool temperature and suspended particle paths provide evidence that the water exiting the lower Swan Pond is already derived from much of the water column. It is also important to note, that during the day of monitoring, it appeared that floating debris substantially blocked the entry of surface waters into the narrow opening of the outflow pipe. However, if this debris was not present, there would be an increased likelihood of more, warm surface water entering the outflow and potentially impacting downstream temperatures.

The lower pond's two surface water temperature readings were much warmer than their deeper values. Of the twenty-two instantaneous measurements taken, these two surface temperatures were the only ones that even exceeded the Washington State criteria (17.5 degrees Celsius measured as the *7-day average maximum temperature*) for water temperature that applies to Tenny Creek, the stream that flows through the Swan Ponds facility. The lower pond's surface waters near the outlet and in the middle of the pond were 6 and 3.5 degrees Celsius warmer than their respective waters only 0.5 feet deeper. Even, field staff observed a very noticeable temperature drop from the surface to a few inches below the surface with just their hands during monitoring. The temperatures of the deepest waters in the lower pond were the coldest measured and very similar; 13.4 and 13.6 degrees Celsius near the outlet pipe and at the middle of the pond, respectively.

The lower pond was stratified with the temperature dropping especially rapidly between the surface and 0.5 foot depth. If the weather is calm and hot, a strong thermal discontinuity (metalimnion) can begin at the surface and could move deeper as wind mixing establishes a stratum of more uniformly warm water near the surface (Wetzel, 1983). The Swan Ponds' water surfaces are probably substantially heated by their direct exposure to solar radiation during the summer. In addition, wind induced mixing is inhibited by the sheltering effect provided by the depression containing the ponds, the surrounding tall trees, and a shore-to-shore dense mat of duckweed in the lower pond. Below 3 feet deep in the lower pond, temperatures decreased much more slowly with increasing depth.

On this particular monitoring day, there was only a 0.6 degree Celsius increase in temperature due to the Swan Ponds based on the temperature difference between their inflow and outflow. The temperature increased from 14.5 to 15.1 degrees Celsius from the ponds' inflow to their lower outflow. Even though the temperature measurements only represent instantaneous values and not averages of 7-day maximums, the outflow temperature still remained well below the state standard of 17.5 ° Celsius during this likely worse case period. The previous year's outflow maximum daily and 7-day average of daily maximum temperatures occurred, respectively, on July 10 and July 20, 2003 (Schnabel, 2004). The July 10, 2003 daily maximum outflow temperature of 17.3 ° Celsius was 2.2 degrees warmer than the current July 23, 2004 outflow temperature of 15.1 ° Celsius.

Most of the difference between the current outflow temperature and last year's maximum daily temperatures could be due to year to year variation or this year's temperature not being measured at the absolute maximum for the season. Additionally, the latest temperature measurements were made at the top of the outflow's riser whereas last year's were made at the bottom after mixing slightly with the warmer surrounding air. Coincidentally, the maximum daily air temperature (103 ° F) occurred only an hour after completion of the monitoring and represented a record high for July 23 (The Columbian, July 24, 2004) at the Pearson Air Field five miles to the south. The mid-day record high temperature likely represented a worse case scenario period of maximum solar heating of the Swan Ponds facility. This was because it was chronologically preceded by respectively; very warm daily highs of 85 and 97 degrees Fahrenheit and nightly lows of 60, 59, and 60 degrees Fahrenheit.

Summary

- The lower Swan Pond is strongly stratified with the surface water being substantially warmer than its deeper waters. The pond's surface waters in the top 0.5 feet are much warmer and isolated from the deeper cooler waters that extend down to between 4 and 5 feet deep.
- It does not appear that the outflow from the lower pond was restricted to waters from the pond's surface.
- The relatively small increase in temperature between the inflow and outflow suggest minimal thermal impact to the Creek.

Conclusion and Management Recommendations

Therefore, it is recommended that:

- A low maintenance retrofit of the outflow riser pipe is added to ensure a more permanent and consistently cool subsurface outflow.
- Any future retrofits should maintain the floating vegetative on the lower pond to help insulate deeper waters unless other rooted macrophytes become established.
- Any future outlet retrofit support pond volumes adequate for water quality treatment and sustaining the insulating properties of the pond's stratification. This would help ensure a cool source of water to optimize downstream temperatures.

References

Campbell, Scott. (July 24, 2004). *The Columbian*, The Columbian Publishing Company, Vancouver, Washington.

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Wetzel, Robert. (1983). Limnology (2nd Ed.). Saunders College Publishing – Harcourt Brace Jovanovich College Publishers, New York.